STATUS OF THE SIS100 HEAVY ION SYNCHROTRON PROJECT AT FAIR

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Abstract

The construction of the modularized start version of FAIR (Facility for Antiproton and Ion Research) [1] has been started. Major civil construction measures, e.g. the site preparation and the drilling of the 60 m deep building foundations are presently being implemented. Procurement of components of the accelerator facilities with long production times has been launched and the design and set-up of the corresponding series test facilities at GSI and CERN are under preparation. The final phase of collision checks and approval of the building planning is presently carried out and the tendering of the execution of the main construction work is under preparation.

SIS100/300 BUILDING

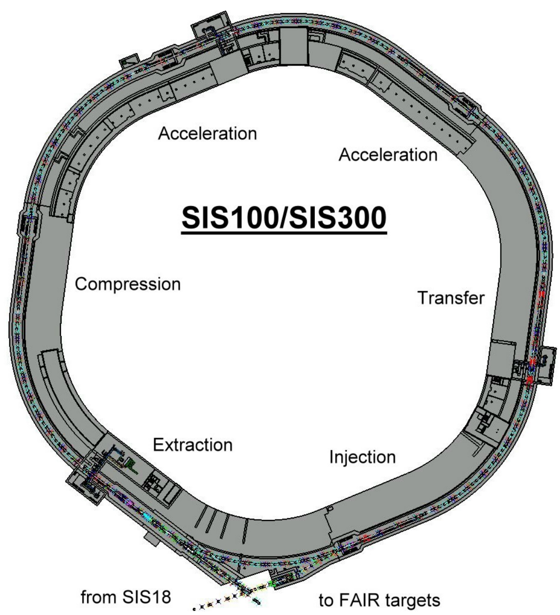

Figure 1: SIS100/300 accelerator tunnel with its parallel supply tunnel. Indicated are the main functional sections of the six SIS100 straights. The three niches (down left and right and up) comprise the local cryogenics system of SIS100. One further niche in the north is foreseen for a later set-up of a laser cooling system.

The architectural planning of the underground building of SIS100/300 is completed (figure 1). For the final approval, a collision check of the architectural design, the ventilation engineering, the cable routing and other infrastructure systems, with the digital mock-up of the accelerator is presently performed. The tunnel building comprises partly up to three floors which in certain areas reach the ground level.

The high energy synchrotron SIS300 is not part of the modularized FAIR start version. However, the tunnel and its parallel supply building have been prepared for a later accommodation of SIS300 which is presently part of FAIR stage 6 (figure 2). SIS300 and HEBT300 will be mounted on the tunnel roof with Halfen rails which are part of the building shell.

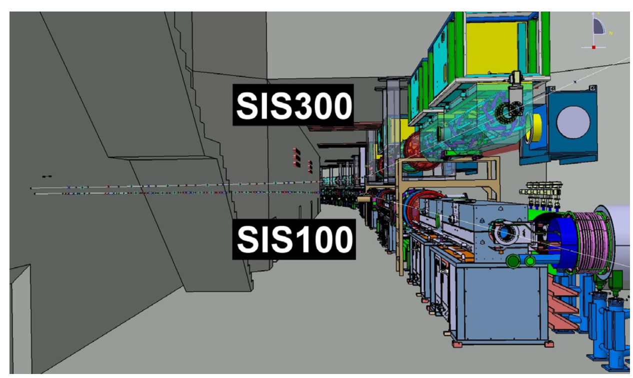

Figure 2: Front view of a straight section with the Rf acceleration systems of SIS100 (below) and SIS300 (top) and the connection box of the cryogenic bypass lines (right) which bridges the warm insertions.

The building planning accounts for various safety demands such as, fire protection measures, e.g. six smoke sections and a dedicated smoke extraction system, high pressure smoke screening system, buffer storage for activated air and primary and secondary cooling water circuits for activated cooling water. The parallel supply tunnel hosts the supply units of all accelerator components and is also used for transportation and for the distribution of the liquid Helium via three main transfer lines. The transfer lines supply the local cryogenics systems with its feed boxes of SIS100 situated in the three niches on the outer side of the accelerator tunnel.

On the inner wall of the accelerator tunnel, several smaller niches are foreseen for front-end electronics of the beam instrumentation system. Furthermore, one niche with an opposite supply area in the northern section of SIS100 is foreseen for a later construction of a laser cooling system.

The injection and extraction systems of SIS100 are linked to the existing GSI accelerator facility, with the booster synchrotron SIS18 on one hand, and on the other hand with the FAIR user facility and its production targets. The injection and extraction beam lines are installed in sloped tunnels with inclinations of 15 and 10 degrees. Building 4, situated just south of the SIS100/300 extraction system, accomodates a complicated 3D structure of beam lines (partly parallel), with switch yards and crossings. The layout of the HEBT topology allows parallel user operation with beams from SIS100, SIS300 or from the booster SIS18. For the supply of the individually powered magnets of the superconducting HEBT 300 beam line, a large supply area in building 17.1 had to be allocated. This area hosts an extended current lead box system and is connected via a cold link to the HEBT tunnel by a vertical shaft.

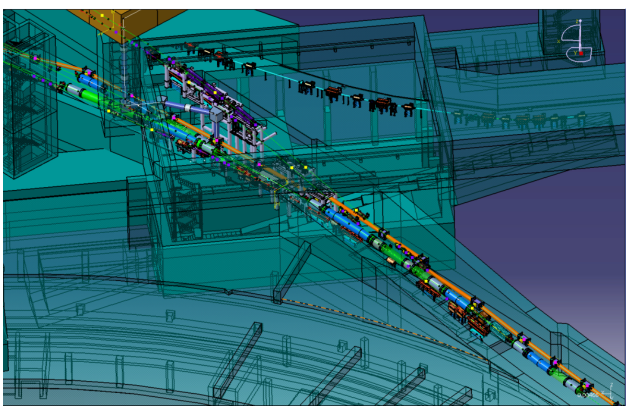

Figure 3: The FAIR high energy beam transport (HEBT) system in building 4 with vertical transfers and sloped beam lines from the underground SIS100 (down, right) to the targets on ground level (middle, up). Furthermore, shown are the two parallel beam lines of HEBT 100 and HEBT 300, on top of each other, guiding the beam to the CBM/HADES experiments situated on an intermediate level (left, up).

INKIND CONTRIBUTIONS

The FAIR inkind review board (IKRB) has assigned a large fraction of the components of SIS100 and HEBT as inkind contributions to various FAIR member states. A major part of the SIS100 components will be built as German inkind contribution, e.g. the superconducting dipole magnets, the dipole power converter, the bunch compression cavities, several injection and extraction components and standardized components like the low level Rf systems and the adaptive controle units of the power converters. The JINR, Dubna has expressed interest in building the second major part of the cryogenic system, the SIS100 quadrupole modules. Since the quadrupole modules contain also parts of the UHV and beam instrumentation system, this work package will potentially be realized in collaboration between GSI and JINR. JINR has also proposed all electrical, cold and hydraulic, and field quality assurance measures for the quadrupole units. The so called units consist of the quadrupole magnets and the attached corrector magnets which share a common cooling circuit. GSI, who is in charge of the module design, will deliver on short term (end of July 2013) the production ready documents for the selected arc module. The selected module comprises most of the components and shall be built as pre-series module by JINR/GSI. Figure 4 shows the present design status of this module, which shall be completed until end of 2014.

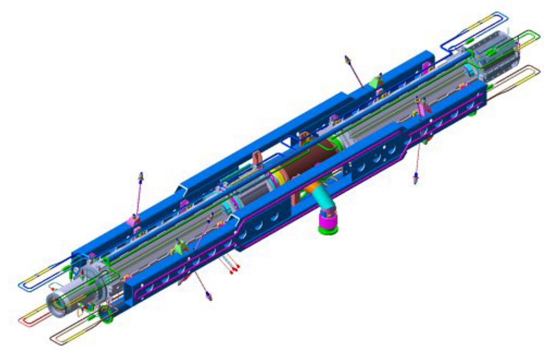

Figure 4: Design of the cold mass of the SIS100 quadrupole module. Two quadrupole magnets and corrector magnets (steerer and sextupole) are installed on a common girder. In between the quadrupole magnets, a cryogenic ion catcher is mounted. The catcher chamber will also be used for roughing the UHV system. A BPM is attached to the yoke of the first (left) quadrupole magnet. The module accommodates the s.c. bus bar system of the dipole and of three quadrupole circuits.

The delivery of the cryogenics infrastructure, the so called local cryogenic system, has been proposed as inkind contribution by Poland. As proposed, the Jagiellonian University will coordinate the production of all major components of the local cryogenics system, e.g. the feed-boxes, the bypass lines, the current lead boxes, the feed-in lines, the connection boxes and others. India, represented by the Bode Institute, has expressed interest in delivery a large fraction of the power converters for SIS100 and the HEBT system. An important part of the beam instrumentation- and controls system shall be built and delivered by Slowenia. Other major components which have not been assigned as inkind contributions, like the ferrit acceleration systems, are presently in preparation for tendering by the FAIR GmbH.

PROCUREMENT STATUS FOR SIS100

Production of several major accelerator components of

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SIS100 has been started. The contract for series production of the fast ramped superconducting dipole magnets has been signed end of 2011. The final design review has been passed in October 2012 and the delivery of the pre-series dipole magnet is expected for June 2013. In comparison with the prototype dipole magnet, the pre-series magnet will show major technical design changes.

A major change concerns the coil design. Due to the cooling requirements at continous triangular operation, a single layer coil (instead of two layers) has to be foreseen. The single layer coil has to carry a current of 13 kA, which is twice the current of the succesfully tested prototype magnet [3].

In parallel, for testing the pre-series magnet with the enhanced current, the existing test stand for superconducting magnets at GSI had to be upgraded. A new power converter for a maximum current of 20 kA and a ramp rate of 42 kA/s has been built and is presently commissioned. Dedicated HTS current leads for the same currents and ramp rates are under development by an industrial partner and shall be delivered in June 2013.

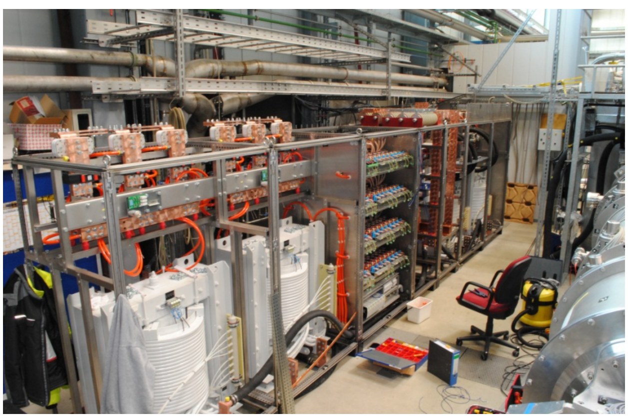
Figure 5: 20 kA power converter upgrade for the existing superconducting magnet test stand at GSI.

Like the pre-series dipole magnet, the series of 110 magnets will also be tested at GSI. The cryogenic supply system for the three test banches is in preparation and the construction of a dedicated annex building on side of GSI is under planning. Design and construction of the cryogenics system and the series test stands, with the option to adapted a string test, has been contracted.

In parallel, to the start of the test campaign of the pre-series dipole magnet, the pre-series dipole chamber will be built and delivered. The thin-wall chamber, with a wall thickness of only 0.3 mm requires active cooling. Cryogenic magnet chambers play an important role for the SIS100 machine function. The cryogenic surfaces of the chambers contribute signficantly to the overall pumping power and are therefore essential for the stabilization of the dynamic residual gas pressure during high intensity heavy ion operation [4]. Four He cooling tubes are attached to the ribs of the UHV chamber and provide sufficient cooling to stabilize the chamber temperature to values below 12 K.

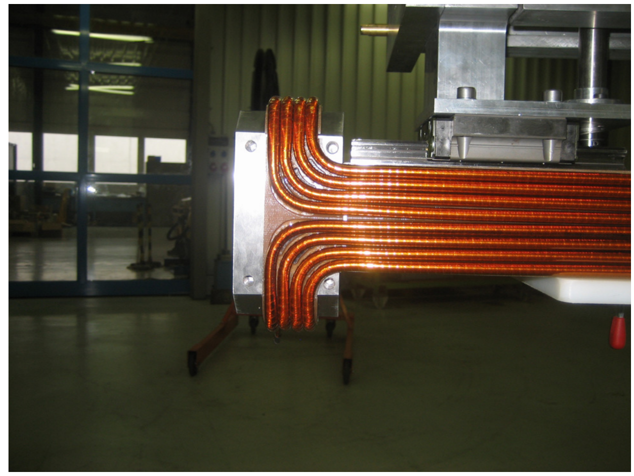
Figure 6: Picture taken during the production process of the coil head of the SIS100 pre-series dipole magnet. Winding of the stiff Nuclotron-type cable, with enhanced cross section along the small radius of curvature at the coil heads has turned out to be demanding. However the specified tolerance could be maintained.

LINK EXISTING FACILITY

In order to prepare the existing accelerator facility of GSI for the FAIR booster operation, an upgrade which comprises most of the main technical subsystems has to be completed [5]. A large fraction of these work packages, e.g. the NEG coating of the UHV chambers, the installation of more powerful injection system and the installation of a warm ion catcher system could be finalized. Two important work packages, the installation of a new acceleration system and the upgrade of the main dipole power converter, have not been completed yet and shall be realized within the next three years. The first of three new MA loaded acceleration cavities, which in the final stage shall provide a total Rf voltage of 50 kV, will be installed in June 2013 [6]. The upgrade of the main dipole power converter will enable a fast ramping with 10 T/s. The power converter upgrade has been contracted recently. Commissioning of the new power converter is planned for the beginning of 2016. In addition to the accelerator upgrade, major civil construction measures have to be taken to provide the required shielding for the enhanced Proton and heavy ion intensities and the increased repetition rate of 3 Hz. A support structure will be installed on top of the whole synchrotron tunnel which is able to carry the weight of an enhanced amount of earth. Further measures are required for handling the activated air and to prepare the link to the new FAIR accelerators.

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